

8. “Impacts on climate variability and change”

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1. Introduction

1.1 Thematic Context

Africa has already been identified by researchers worldwide as a continent particularly vulnerable to the consequences of climate variability and change (Odada et. al 2008). The recent fourth assessment from the Intergovernmental Panel on Climate Change (IPCC,2007) looking at vulnerability also confirmed it. The effects of climate variability and change are already evident on the ground and the continent’s policymakers cannot afford to ignore it anymore (Stern,2007)

Many countries in Africa depend on natural resources that are sensitive to changes in climate. Water supplies, for example, already suffer from high rainfall variability in many parts of the continent. With reservoir levels already dangerously low, projected changes in climate look set to put further pressure on water availability, which may lead to conflict and are certain to affect economic development (World Bank,2005) Land conditions, especially in areas already vulnerable to degradation, are expected to deteriorate under climate change, and new fragile drylands can be created.

Climate variability and change is likely to affect food security as well. Over half the African population live in rural areas, dependent on the local environment for food. But the marginal cropping conditions in semi-arid and sub-humid area, where rainfall is extremely unreliable, have already led to widespread malnutrition. Further climatic variability and change could leave many African countries reliant on food aid from the developed countries (UNDP,2004)

Climate variability and change will affect not only natural resource bases but could also have implication for human health. Vector-borne diseases such as malaria are already placing national healthcare systems under strain. Such diseases are driven in part by climate change with several Africa countries experiencing increases in Malaria outbreaks that can largely be explained by recent changes in temperature and rainfall (IPCC,2007)

1..2. Pressures/Constraints: Impact of Climate Change

Climate change has long since ceased to be a scientific curiosity, and is no longer just one of the many environmental and regulatory concerns. It is the major, overriding environmental issue of our time, and the single greatest challenge facing decision-makers at many levels. It is a growing crisis in economic, health and safety, food production, security, and other dimensions. Shifting weather patterns threaten land conditions and related food production through increased unreliability of precipitation, rising sea levels contaminate coastal freshwater reserves and increase the risk of catastrophic flooding, and a warming atmosphere aids the pole-ward spread of pests and diseases once limited to the tropics. While, the exact nature of the changes in temperature,

precipitation is not known, there is agreement about the following table of multiple impacts of climate variability and change in Africa that will need to be addressed by adapted and knowledge based policies:

Table. Impacts of Climate Change and Variability

Resources	Impacts
Humans	<ul style="list-style-type: none"> • Decreased agricultural production and food security. • Reduced water availability. • Increased pests and diseases. • Human conflicts over resources.
Animals	<ul style="list-style-type: none"> • Loss of biodiversity. • Loss of habitats. • Increased pests and diseases. • Increased human/animal conflicts.
Plants	<ul style="list-style-type: none"> • Loss of biodiversity. • Loss of habitats. • Increased invasive species.
Land and Ecosystems	<ul style="list-style-type: none"> • Worsening of land degradation. • Increased areas under Desertification and Deforestation. • Unfavourable land Transformations. • Increased hazard for vegetation Burning. • Change of land cover.
Water and Ecosystems	<ul style="list-style-type: none"> • More events of drought and flooding • Loss of biodiversity. • Loss of wetlands. • Groundwater pollution. • Sea-level rise. • Snow and glaciers melting.

2. Policy Drivers and need analysis.

2.1 Policy drivers

National decision makers are flooded with urgent demands for action on a wide range of issues, and must make choices among them. A major factor influencing such decision is the prospective return on investment, as demonstrated by the impressive impacts of the Stern Review on the Economics of Climate Change (DLD, 2009). Information that satisfies such demand is needed as first priority. Information on the changing environmental status and climate change impacts will be needed in the argumentation or negotiation phases of policy making and international treaties. On the contrary, climate observing system in Africa is currently the worst in the world and is deteriorating. Ways of securing climate observing and integrating climate information into development are therefore urgently required. Africa need to build effective partnership systems linking stakeholders, users and decision-making sector with climate information providers (including climate prediction providers, climate observation providers as well as climate operational sectors). Synergies with sister conventions, UNFCCC, CBD, are rather obvious and need to be consolidated optimizing use of resources, obtained information and reporting obligations.

The Global Monitoring for Environment and Security (GMES) European Initiative that is currently on the political agenda of the European Union (EU) and the Arican Union (AU) can provide on a sustained basis, reliable and timely services related to environmental and security issues in support of public policy makers needs as stipulated in the joint EU-Africa strategy document of October,2006. GMES has a global reach and can contribute to the international efforts consistent with the Johannesburg 2002 Action Plan, the Mauritius Strategy

for small island developing states (SIDS) as well as with G8 recommendation made in July 2005 to strengthen the global climate observing system.

The Lisbon Declaration on “GMES and Africa” of December 2007 also recognized that the environmental degradation and climate change undermine sustainable development and represent threats to the achievement of the Millennium Development Goals (MDG’s). The EU is therefore committed to support Africa’s capacity Building efforts in the sustainable management of natural resources, including on weather observation, climate monitoring and early warning systems, as well as helping to tackle illegal logging and associated trade. The strategy recognized also that in order to achieve the MDG’s, a special global effort to build scientific and technological capacity in Africa is required and thus inadequate technical capacity of Africa will be upgraded inter alia through specialised networks at regional and sub-regional levels, focusing on identified priorities so as to underpin economic growth and sustainable development of the African Continent.

2.2 Need analysis

The Intergovernmental Panel on Climate Change (IPCC) and many other recent assessments have shown that Africa is one of the most vulnerable region to the negative impacts of present and any future climate variability and change. Availability of long-term, high quality data with good spatial coverage that is representative of all climatological zones , is critical for understanding past and present climates as well as projecting climate expectations of the future; assessment of the impacts and vulnerability; and the development of appropriate mitigation and response policies.

The parties to the United Nations Framework Convention on Climate Change (UNFCCC) have recognized the importance of improving climate related observations to meet convention needs, and in a series of decisions, have urged parties to take actions to improve all types of observations, including atmospheric, oceanographic and terrestrial components of the climate system. The Global Climate Observing System (GCOS) was therefore established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users.

GCOS and its regional partners in Africa (e.g. the Drought Monitoring Centre in Nairobi-DMCN and Harare (DMCH) have identified regional deficiencies and needs in atmospheric, oceanographic and terrestrial observing systems for climate monitoring and developed regional plans and projects to address the identified needs. The three major regional issues that were identified include:

- (i) Establishment of regional system for monitoring changes in the glaciers of the tropical mountains of Eastern Africa;
- (ii) Development of some urban climate/air pollution observation system and
- (iii) Development of regional climate change data and information centre to enable the region undertake effective climate change monitoring; detection; attribution; together with assessments of the impacts/vulnerability of the society;and development of appropriate mitigation and adaptation policies.The specific activities currently undertaken are outlined below:

OBJECTIVES	ACTIVITIES
1.Establishment of regional mountain glacier observing system and information/database.	1.1 Identify and delineate location of glaciers to be monitored. 1.2 Survey/develop baseline reference points for monitoring using all possible methods in space based methods. 1.3 Set up automated climate observing stations at the three mountains. 1.4 Set up relevant automatic hydrological system. 1.5 Develop relevant Model of the glaciers, climatic, vegetation, Hydrological and other relevant data. 1.6 First assessment and statement regarding the state of glaciers at the three mountains.This would be the reference baseline for all future assessments. 1.7 Conduct capacity building workshops. 1.8 Publication and Exchange of relevant information; and annual statement regarding the state of the regional glaciers. 1.9 Regional education and awareness workshop. 1.10Develop short, medium and long term capacity plan to ensure

	<p>sustainability of the observation programme.</p> <p>1.11 With some potential partners like START, PAGES etc; undertake some ice core studies to understand past climate variabilities and changes.</p>
2. Development of national and regional climate change indices database Centres.	<p>2.1 Identify data that may be relevant to regional climate change, detection and attribution including re-analysis, space based and model output products.</p> <p>2.2 Identify GCOS regional data adequacy including regional data / observation network.</p> <p>2.3 Develop framework for rescue and storage in digital form of regional data currently in magnetic tapes.</p> <p>2.4 Conduct capacity building training workshops on GCOS data quality control, data mangement; climate change indices, etc</p> <p>2.5 Develop appropriate formats for data storage on appropriate media and design.</p> <p>2.6 Acquire relevant equipment for data rescue, data processing and software for the NMHS's.</p> <p>2.7 Set up a regional / national climate change database centres.</p> <p>2.8 Purchase install hardware and software at the NHMS's and ICPAC.</p>
3. Establishment of urban climate and air pollution observation platforms, and data base.	<p>3.1 Workshop of experts and national representatives on urban climate change and pollution monitoring to address regional requirements.</p> <p>3.2 Assess suitability of the existing meteorological stations for incorporations into the urban observing network.</p> <p>3.3 Development of one platform per country on urban climate / urban air pollution measurements.</p> <p>3.4 Develop national and regional data base on urban climate/ urban air pollution for the countries.</p>

In addition to the above initiatives, the scientific community recently formulated the user needs related to monitoring and assessment of desertification/land degradation (DLD) (DSD WP1, 2009) and listed that all users groups needs to have information at hand to be able to derive:

- the spatial location, severity and extent of DLD
- nature of DLD, e.g. loss of primary production, impacts on water resources, etc.
- the cause of DLD and what are the options to counter these
- Hazards and risks
- financial considerations and the social implications of mitigation

Such information needs are similar in other fields of the above identified climate variability impacts and require integrated assessments that will need to be based on earth observation data providing the spatial continuum to be complemented with in-situ observations.

(a) Knowledge and methods:

Pijanowski, B.C.. et al. (2007), describe very well the need and requirements of integrating climate-land change interactions: "Understanding the interplay of interactions between the human-environment system and the climate change, requires assessment of how various factors within the climate system, such as temperature, precipitation patterns, impact on the human behaviour and socio-economic systems. Behaviourial and socio-economic factors influenced by climate, include food production systems, crop prices and market dynamics, human behavioural factors such as risk and cultural norms, migration and population dynamics and land tenure systems. Land use/cover properties in combination with bio-physical factors such as topography, soils, influence of large water bodies, combine with atmospheric trends such as greenhouse gas concentrations, to loop back to regional and global climate change dynamics."

This confirms the need for knowledge and understanding of interrelations of drivers and impacts in the cause-effect of climate change. However, there is a lack of standardized procedures and methods to perform this at operational scales. Building required capacity and knowledge bases, together with the routine provision of

focused spatial information products, whether derived from satellite imagery and/or integrated with ground observations, can be obtained through a focused and continent wide programme that includes all key stakeholders. GMES is an excellent basis for such contraction.

(b) Analyzed and integrated Information

Spatio-temporal analysis of the above in point 4. mentioned impacts should reveal fields where relevant management options to counter them can be identified.

Cost-benefit analyses are needed that includes the value of environmental services. Not all values are monetary; the land provides a range of ecosystem services that are beneficial to humans in tangible on intangible ways, such as culturally.

International payments for carbon sequestration linked to the proposed United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme, <http://www.un-redd.org/>) mechanism under the UNFCCC could generate financial resources for dryland countries.

(c) Products

Inherent to the subject, products wil need to be produced at regular intervals. Results will need to be presented in user adapted understandable formats, and more science-to-policy dialogue is needed for that. Ideally product definition are obtained through an iterative scoping process that includes stakeholders from producers of data to users at technical and political levels.

Impacts	Needs and Potential Products (examples only. not exhaustive)
<ul style="list-style-type: none"> • Decreased agricultural production and food security. • Reduced water availability. • Increased pests and diseases. • Human conflicts over resources. 	<ul style="list-style-type: none"> - statistic and satellite based production estimates (including NDVI derivates and RFE) - integrated info from RFE, Soil properties, Cloud presence, DEM, groundwater resources (sat. based soil moisture products), etc. - inventory of main ecosystem service resources: based on satellite info on vegetation land cover, Soil Organic Matter, Ground water, livestock densities, habitat characterization
<ul style="list-style-type: none"> • Loss of biodiversity. • Loss of habitats. • Increased pests and diseases. • Increased human/animal conflict • Increased invasive species.ts. 	<ul style="list-style-type: none"> - habitat characterization; dynamics based on long term low resolution sat. data; habitat patterns, segmentation and connections calculated on combined ground and space based information; and land cover/use based on multitemproal high resolution imagery - spatial databases on plant species composition, biodiversity 'needs' and pest occurrence
<ul style="list-style-type: none"> • Worsening of land degradation. • Increased areas under Desertification and Deforestation. • Unfavourable land Transformations. • Increased hazard for vegetation Burning. • Change of land cover. 	<ul style="list-style-type: none"> - products on state and trends of the key state variables, vegetation and soil, complemented with spatial continuous climate data and soico-economic data layers., - satellite derived burn scar products

<ul style="list-style-type: none"> • More events of drought and flooding • Loss of wetlands. <ul style="list-style-type: none"> • Groundwater pollution. • Sea-level rise. <p>Snow and glaciers melting.</p>	<ul style="list-style-type: none"> - interpolated rainfall products and drought indices, such as SPI and anomaly products. - high resolution DEMs,
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3. Identification of Communities

The European and African users communities and stakeholders to be engaged in “GMES and Africa” initiative include the following:

European institutions and agencies	DG DEV, DG AIDCO, DG ENV, DG AGRI, EEA National, regional or local governments among EU Member States and Partner countries	need the information to assist policy development and implementation need the information to assist for policy development and implementation and to help mandatory reporting requirements (e.g National Development of Foreign Affairs)
African institutions and agencies	AU, UNECA, ECOWAS, IGAD, CEMAC, SADC, SIL, IOC, NEPAD, AMCOW, AMCEN, AMCST, National or local governments among AU Member States and Development Partners	need useful information on a wide range of areas such as food security, management of natural resources, desertification, climate monitoring, conflict prevention and humanitarian aid need the information to assist for policy development and implementation and to help meet mandatory reporting requirements (MDGs, UNFCCC, UNCCD, UNCBD, etc)
International institutions and development partners	UN System’s Organizations, World Bank, Global Environment Facility, European Commission,	helping African countries build and fund environment, development and disaster reduction programmes need the information for the development of their policies and operational strategies and to direct the utilization of their resources in the continent
International initiatives and bodies	WMO, GCOS, IPCC International agencies: FAO-GIEWS, UNEP-DEWA, ECMWF, JRC-ACP Observatory, JRC/FOODSEC and AGRI4CAST, World Bank, UNHABITAT, UNDP,	in support of international conventions (e.g UNFCC, UNCCD, UNCBD) operate their own Early Warning and Monitoring Systems from continental to global scales
Scientific Research programmes	RCP, IGBP, IHDP, START, DIVERSITAS, ESSP, AfricanNESS	working in Africa on improving the understanding of the processes and

		uncertainties associated with Earth System Science
Private sector	cash crop production, mining, infrastructure, forest exploitation, non-governmental organizations (NGOs) civil society	Need for policy direction and project implementation, to access understandable and reliable information on global environmental trends for public participation on decision making.

4. Mapping Exercise

This is aimed at the identification of relevant past and current activities (e.g. infrastructure), existing capacities and programmes in Africa as well as in Europe on which “GMES and Africa” can build on (including the work done by the GEO capacity building committee and other international experience (e.g. capacity building - education, training and research); key institutions (at national, regional and continental levels), including networking (thematic, geographic, etc).

<i>Initiatives</i>	<i>Specific programmes</i>	<i>Nature and basis for linkage</i>
GEO	GEOSS, Terrestrial component of GCOS, GTOS IGOS CEOSS/LSI	<ul style="list-style-type: none"> • achieve a stronger role in international organizations, consolidating the European contributions to the GEO/GEOSS • enhance delivery of benefits to society in understanding, assessing, predicting, mitigating, and adapting to climate variability and change • providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modeling and prediction of the climate system. • to address the effects on food security, the environment and sustainable development • to produce comprehensive global, region, and national data and information • to define standards (or guidelines) based on a thorough understanding of user requirements that describe optimal future LSI constellation capacities, characteristics, and practices. • aims at promoting the efficient, effective and comprehensive collection, distribution, and application of space-acquired data of the global land surface.
European international initiatives	GMES LMCS	<ul style="list-style-type: none"> • provide information concerning global land surface processes and strengthen capacity for international cooperation on regulatory issues and enhance Europe's in the development of global standards
African institutions and initiatives	regional partners of GCOS in east and southern Africa and Drought Monitoring Centres in Nairobi	<ul style="list-style-type: none"> • to identify regional deficiencies and needs in atmospheric, oceanographic and terrestrial observing systems for climate monitoring and to develop regional plans and proposals to address the identified priority needs. • monitoring changes in the glaciers of the tropical mountains of eastern Africa;

		(DMCN) and Harare (DMCH)	<ul style="list-style-type: none"> • development of some urban climate/air pollution observation system, and • development of regional climate change data and information centre to enable the region undertake effective climate change monitoring; detection; attribution; together with assessments of the impacts/vulnerability of the society; and development of appropriate mitigation and adaptation policies.
African research activities	GEC	AfricanNESS	<ul style="list-style-type: none"> • food and nutritional security, including crops, wild-gathered resources, livestock resources and fisheries; • water resources, particularly in the water limited sub-humid, semi-arid and arid regions; • health, especially in relation to the biodiversity-linked, environmentally-mediated and vector-borne diseases that are responsible for the high disease burden in Africa, and • ecosystem integrity, on which the presence of biodiversity and the delivery of ecosystem services depends (Odada et. al., 2008). • outlines the kinds of international, multidisciplinary research approaches necessary to approach these issues, give examples of specific questions and projects.

5. Identification of Gaps and Suitable Programmes

5.1 Identification of gaps.

A. Thematic gaps.

The major gaps where “GMES and Africa action is needed are Land and Water knowledge and information. Land processes are characterized by a great complexity associated with the multiple elements in play and various relations between these elements. Land resources are the most important basis of African communities’ survival. Over the years, following various human and natural shocks, land resources have been seriously damaged with serious environmental and socio-economic consequences. This degradation process has international connections both from its origin (globalization, multinationals, climate change etc) and in terms of its impacts (climate change, poverty issues). Improvement of land resource management in Africa is becoming a central concern of the international community and is acknowledged by several UN Framework conventions (UNCB, UNCCD, UNFCCC) but links need to be consolidated with these conventions.

B. Data gaps

* Institutional capacity: Up to date, no harmonized data collection systems are in place. Data gathering in-site at national level is not fully coordinated and if data is collected for one purpose it might not be available to other stakeholders for other use. In many cases institutional capacity or motivation is missing to cover less common, but needed, data needs.

* Data collection methods and storage are mostly dispersed and not harmonized. The scientific community therefore proposed the development of a GDOS system (Global Dryland/Desertification Observing System)(DSD, 2009).

* Baselines for most of the variable and integrated products need to be compiled.

C. Methodological gaps:

Earth Observation is complementary, not alternative, to in-situ observations, but provides a good basis for spatio-temporal integration of both data types. Contextual knowledge acquired in the field can be used to orient and calibrate the satellite data analysis. Obviously for DLD long term satellite data series are needed to derive required trends. Ideally higher resolution, spectral better focused and more consistent satellite data series have less time span, e.g. SPOT VGT has 10 years now. However, these should be combined with the available long term series through innovative approaches.

D. Knowledge gaps

These analyses for climate change impact purposes need to better integrate climate aspects to provide further understanding of the cause-effect relations that can lead to identify potential fields for adaptation management and policy orientation. For climate change impact assessment, earth observation can provide data required to drive e.g. water regulation models and carbon models. However integrating of bio-physical, including climate aspects, and socio-economic aspects is the only way to obtain relevant information. Holistic assessments are only at the brink of development and need to be further developed.

6. Building GMES and Africa Service

6.1 Service definition and provision

(a) Basic Services to be set up and provided need to focus on the provision of data and information:

Data acquisition services include:

* From regional, national, local institutions

- Harmonized meteorological information
- Harmonized in-site bio-physical and socio-economic observations

* From the space segment

- Earth Observation data for the elaboration of the following continuous harmonized datasets:

- Factors of the climate system:

- Temperature, Precipitation patterns, radiation, albedo, evapotranspiration, Wind, Sunshine, Greenhouse gas concentrations.

- Bio-physical

Land cover – land use – and change:

- Land cover and land cover change maps, land use and management information (high spatial resolution based imagery with temporal update of 5 years – FAO Africover and GLCN networks provide basis for this)

- Vegetation changes, e.g trends in cover density, trends of phenological parameters and productivity: (based on long term low resolution times series)

DEM, geology

Soil property/soil condition trends, e.g of SOM, salinity, moisture, erosion etc.

Larger water bodies.

For many of the above non-exhaustive list of data requirements, space born observations can contribute to the compilation and integration into spatio-temporal continuous datasets and the build up of highly necessary time series. E.g. Multiple satellite and sensor merging techniques can be used to improve the precipitation estimates from space. Advantages are a better spatial resolution, a continuous temporal coverage and constant know uncertainties.

A minimum time series length will be 10 years, allowing the understanding of interplay between certain bio-physical and climate factors. Longer time series are needed for trend analysis.

(b) Advanced services:

Specific variables measured by space systems can be directly assimilated into relevant process models where it concerns climate change assessment. However, for the impact assessment of climate variability and change it is not sufficient to define a set of primarily physical or categorical variables which drive a single generic model.

Therefore, products to be serviced will have different levels of integration. The White Paper prepared for the UNCCD scientific conference (DLD, 2009) provides insight in various modelling techniques that are available for producing integrated assessment products. One of them is e.g. syndrome or scenario based modelling (Petschel-Held et al., 1999). This looks at large scale processes and interactions. Impacts, such as from climate variability, are characterized by a suite of properties that affect resources, economies and populations. Syndromes, well known in land degradation assessments, link such state or symptomatic variables and can be used to produce spatial products indicating the probability for the syndrome to happen. Being deterministic they can be adapted for scenario building. Key state variables are dependent from the scale and the objective of the integration. Reynolds et al. (2007) propose to focus on slow variables and link these to ecosystem services.

GMES as such will need to provide integrated products. As GMES node, at regional level there will be more competence for processing, hence products are level 2 or higher and can include an advanced level of modelling. For data type and thematic integration, many dispersed science approaches are available, but need to be scrutinized for effectiveness and applicability. This is a research question to be solved first. On-going activities and guidance as provided through the IPCC and the recent science integration into the UNCCD process, can provide further support to solving this issue. Stakeholder participation in such process contributes to understand the various aspect of the complex interactions within the human-environment system. This is field to which GMES can contribute substantially and ensure progress and breakthroughs that lead to higher level information focused on impact identification and mitigation options.

Table : Relevance of identified multi-purpose products
(source: GMES-LMCS WG final report, 2007)

			Application areas	
			Climate change	Desertification
Near Real Time Bio-geophysical monitoring service	Vegetation	Fraction of Vegetation Cover	x	x
		Leaf Area Index		x
		NDVI	x	x
		FAPAR		x
	Fire	Burnt area maps		x
		Active Fire maps	x	
		Fire Radiated power	x	
	Radiation	Land surface albedo	x	x
		Land surface temperature		x
		Surface fluxes - Short-wave		
		Surface fluxes - downward long-wave		
		Emissivity		
	Water	Lakes maps	x	x
		Level of lakes and big rivers	x	x

	Lake surface temperature	x	
	Ground water	x	x
	Actual Evapotranspiration		x
Snow	Snow area extent	x	
	Snow depth	x	
	Snow water equivalent (SWE)	x	
Permafrost	Permafrost extent	x	
	Permafrost depth	x	
	Permafrost seasonality	x	
	Soil moisture (up to 10-cm soil depth)	x	x
Periodical land cover and changes mapping service	MR Land cover and change maps	x	x
	HR Land cover and change maps		x
	HR Forest cover and change maps	x	X
	HR Urban area and change maps		X
	HR Cropland and change maps		X
	Glacier and ice sheet maps	x	
	Ice sheet topography and elevation changes	x	
Other data	Rainfall estimations		x
	Temperature		x
	Land surface topography (DTM)	x	x

6.2 Capacity building

The overarching constraint reported by ministries, agencies, non-governmental organizations, scientists, research projects and others in developing countries, and identified by virtually all studies and reports on the implementation of MEAs, is a lack of institutional, financial and human capacity to address physical and human resources and skills requirements adequately. Capacity affects responses to, and the effectiveness of, monitoring and knowledge exchange, along with the ability to implement treaties effectively (DLD, 2009). Knowledge management can help to overcome this constraint if barriers to knowledge sharing and knowledge management between local, national, regional and international levels are eased. Capacity-building needs to be cross-sectoral to overcome past shortcomings in addressing the complexities of DLDD, including the need to incorporate actions into government agendas, analyses, frameworks and policies. In addition, capacity-building needs to foster greater collaboration and coordination of activities at regional, national and local levels.

This is specifically true in the field of earth observation related to climate change impact integrated assessments. Capacity building needs to construct on improving or operationalizing existing structures. The complex nature, however, of integrated assessment strategically including earth observation data and information, suggests a capacity building that most probably focuses at regional levels first, with secondary extensions to the national scale. European academic institutions, assisted by funding agencies, should play a pivotal and fore front role in not only technology transfer, but also on what is needed to use this technology and to translate it into policy relevant information. Regional and national science-to-policy dialogues should be organized to answer to the latter.

6.2.a Necessary Elements

Besides the requirement of reliable space and in-situ data collection systems, the assessment needed for the successful implementation of the mentioned indicators will to a good deal depend on the creation of a robust information baseline for which monitoring and assessment capabilities include

- common principles of data collection, data handling and reliable methodologies for the integration of available archived data and continuous monitoring data, in view of deriving biophysical and socio-economic trends;
- concepts for streamlining and optimization of the integration of knowledge on biophysical and socio-economic factors and on their interactions;
- improved knowledge and models of the interactions between climate change adaptation, and mitigation and impacts on the human-environment systems;

6.2.b Strategy to Implement Them

Capacities should be built in a way that strengthens existing institutions, increasing the acceptance of the continuing need for monitoring and assessment and its flow into the policy making process. Capacity building starts with knowledge sharing based on proper and adapted knowledge management. It further needs a transparent, active collaboration and coordination of activities at regional and national scales. There are many diverse interest groups, people, governments, institutions, that hold stakes in land issues, monitoring and assessment must utilize multiple knowledge sources at different scales. (DLD, 2009).p12

Once knowledge improves, this catalyzes needs and use of information. The initial capacity is fostered through existing institutional capacity and gradually increased by the process itself of (improved) monitoring, (focused) assessment and (adapted) use of information.

Planned Services under GMES & Africa Initiative will need to deal with a certain initial inertia of product take-up and maybe focus more on knowledge management and transfer than the product generation itself during the initial phase. Such knowledge transfer needs to illustrate the added value of the products for the stakeholder's decision making. Services will need a programme that addresses this gradual process starting from information and product value awareness raising, capacity building to ensure the take-up and use of the products leading toward the product generation itself

Further steps to consider are:

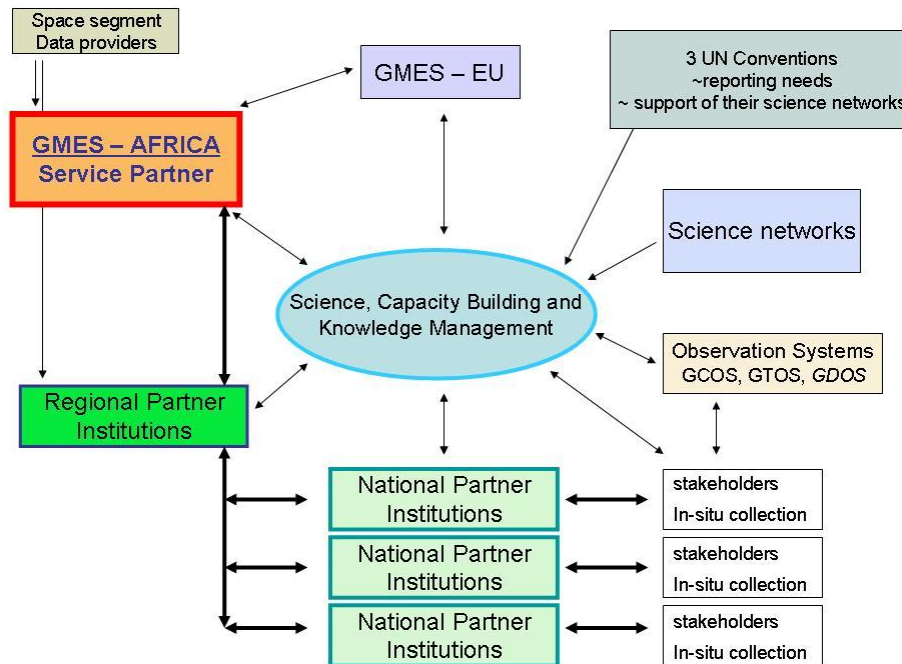
- Organizing and actively running of proper science networking: ensuring a proper, comprehensive and responsive science input into the whole process on a continued basis, a networking and coordination mechanism could be fostered through GMES. This can of course build and group on existing networks.
Activation of monitoring mechanisms such as the existing GTOS and the would-be GDOS, and their linking with GCOS. Other existing initiative can be incorporated and/or reinforced:
 - FAO Africover
 - GLCN
 - OSS-ROSELT
 - Others....
- Finalization of the inventory of all needs and scientific methodological options to satisfy user needs in this thematic field .
- reinforce existing initiatives

6.3 Prioritisation of requirements and actions

(1) Awareness raising at the various institutions involved:
Stakeholder processes for awareness rising from the GMES side and involvement in product definition from the stakeholders at the other side, increasing the ownership feeling and stimulating involvement and sustainability of the process.

(2) Coordination of in-situ observation and data collection
(3) Coordination of compilation of fundamental datasets: from in-situ and space campaigns
(4) Identification and selection of models and methods for integration of data into version 1. products (using science network throughout all process)
(5) Service-stakeholder iterations on use, improvements and increased capacity building
(6) Product generation
(7) User and use follow-up; added value evaluation
(8) Routine production, refinements and continued use adaptation

6.4 Organizational scheme



7. Recommendations

- Working linkages need to be established with identified regional partners and national partners.
- Sensitivity and awareness need to be raised with those partners on the importance of climate change impact monitoring, knowledge management and science based capacity building is at the centre and is driving main interrelations and connections, ensuring sustainability of the GMES set-up.
- Climate change impact assessment and the required data collection need to be based on agreed methodological principles and harmonization procedures
- Sets of key variables need to be identified. Connected science networks and insights gained through e.g. the UN convention community are crucial to be involved
- Data collection, in-situ or space borne, need to be interconnected with on-going initiatives
- Appropriate scientific based knowledge management approaches need to be utilized in the phase of individual need and product evaluation and definition; this also is expected to initiate mobilization of existing capacity; vital gaps need to be identified and addressed

- All partners will need to adopt coherent and open data policies. Clearly identified and properly setup communication channels and access right must be established to facilitate exploitation of all information by all concerned actors, while preserving the rights and addressing the concerns of the original data providers. Such should be coordinated by the GMES-Africa.
- methods for data and thematic integration will need to be identified in collaboration with all partners and the scientific community in the early stage of the programme.

8. Summary

Africa is endowed with immense renewable natural resources. Yet, natural phenomena such as climate change and variability, and human factors, such as population growth, competition over water and pollution, increasingly threaten the sustainability of Africa's natural resources, and hence, the livelihoods of the many poor living in Africa. The continent suffers from one of the most unstable rainfall regimes worldwide, causing severe aridity in areas such as the Sahara and extreme humid tropical conditions in areas such as the Congo Basin. The high temporal and spatial rainfall variability has also repeatedly led to extreme climate events (droughts and floods) that pose a continuous risk to Africa's people and their livelihoods and its national economies.

Climate change and variability, population growth and increasing water demand, over-exploitation and environmental degradation will contribute to a worsening of the state of natural resources in Africa. The over-exploitation and regulation of water resources for example, have caused significant changes in the flow regimes of rivers resulting in negative impacts on the environment and loss of ecosystem functioning. The outcome of poor land use practices has resulted in sedimentation of river channels, lakes and reservoirs and changes in the hydrological processes. Among the many factors leading to the degradation of watershed ecosystems, dams are the main physical threat; fragmenting and transforming aquatic and terrestrial ecosystems with a range of effects that vary in duration, scale and degree of reversibility (World Commission on Dams, 2000). The continent is marked by recurrence of climatic extremes in the form of flooding and drought. Global change scenarios predict a continuing global warming for this century-between 1 and 6°C and a sea level rise of between 0.1 and 0.9m (IPCC, 2001) and an increasing frequency of climatic extremes that may further aggravate the state of available freshwater resources.

Not only is the quantity of freshwater a fundamental instrument in the development of all regions of the continent, but also the quality of the resources. Deterioration of the quality of water resources resulting from further increases in salinity and nutrient loads from irrigation (irrigated agriculture) and the domestic, industrial and mining sectors will significantly deplete available resources and increase water scarcity. Increased human activities lead to the exposure of the water environment to a range of chemical, microbial and biological pollutants as well as micro-pollutants. The mining and industrial sectors especially produce high concentration of wastes and effluents that act as non-point sources of water quality degradation and acid mine drainage. Increased groundwater pollution is a particular concern for the more arid countries of northern and southern Africa. All these challenges will be addressed through the enhanced knowledge, improved data and integration of information by "GMES and Africa" initiative.

Annexes

Summary of relevant reports

(1) The Dryland Science for Development (DSD) White Papers in preparation of the first UNCCD Science Conference (Sep.. 2009) See www.drylandscience.org.

The Dryland Science for Development (DSD) consortium convened three global working groups of scientists to analyse and summarize the leading scientific knowledge on the priority theme on *“bio-physical and socio-economic monitoring and assessment of desertification and land degradation, to support decision-making in land and water management”*, in order to generate practical recommendations. The document describes state-of-the-art knowledge and derives innovative solutions for the monitoring and assessment of desertification, Land degradation and drought. Both the technical aspects, including remote sensing options, integration and solutions . as well as the knowledge management aspects are dealt with in depth. Furthermore, synergies between existing operational systems and the various UN conventions are explored. Final recommendations are formulated for decision makers.

(2) The Roadmap towards a New World Atlas on Desertification, Land Degradation and Drought, describes the context and needs for a New Atlas on DLDD in support of policy framing and to improve the scientific input into policies in that filed. A methodology for regular application of indicator systems for monitoring and assessment of desertification processes is described.

African strategy for GEC,

<http://www.igbp.net/documents/AFRICANESS-REPORT.pdf>

Terrafrica, 2004,

<http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/0,,contentMDK:20221507~menuPK:258659~pagePK:146736~piPK:146830~theSitePK:258644,00.html>

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